

McGee (W. J.)

ANTHROPOLOGICAL SOCIETY OF WASHINGTON

SPECIAL PAPERS

2

THE EARTH THE HOME OF MAN

BY

W J MCGEE

PART OF A COURSE OF LECTURES PREPARED UNDER THE AUSPICES OF THE
ANTHROPOLOGICAL SOCIETY OF WASHINGTON AND DELIVERED IN THE
UNITED STATES NATIONAL MUSEUM



WASHINGTON

1894



THE EARTH THE HOME OF MAN.*

By W J McGEE.



MAN'S PLACE IN NATURE.

Life in the Cosmos.—The earth is the home of living things. The waters of the earth abound in lowly forms of life, beginning with simple beings of indefinite structure made up of undifferentiated protoplasm, running through a long series of successively higher forms, and ending with the vertebrates, of which some belong to the mammalia, and thus approach the highest known life-forms; the air is inhabited by winged insects and flying birds with a few flying beasts, and all of these bees and beetles, birds and bats, are highly organized, while many of the lands of the earth teem with plant and animal life, ranging from the simplest to the most complex in degree of development, in perfection of organization. In addition, the plant-bearing soils of the earth comprise a mixture of plant remains and mineral substances decomposed and recomposed by plant action; and furthermore, most of the rock formations of which the land is made up were originally sediments of the sea bottom and are composed in part of the remains of organisms of past ages and in still greater part of complex chemie compounds due to vital action during the eons of world growth; and these fruits of earlier life stored up in soils and rocks are the germs and nursery of later life. So the air, water, and land abound in living things and the whole earth teems with life and pulsates with vitality.

Living things are distinguished from non-living matter commonly by organization or by an arrangement of parts in definite relation to the whole (e. g., the roots, stem, leaves, flowers, and fruit of a plant, or the heart, lungs, stomach, and brain of an animal), always by a distinctive manifestation of force commonly spoken of as vitality or vital force. Now vital force is manifested by certain highly complex chemie compounds, and is not manifested by matter in other and simpler forms; indeed the more complex, at least, among the higher compounds appear to

*A Saturday lecture delivered in the lecture hall of the U. S. National Museum, under the auspices of the Anthropological Society of Washington.

Spec. Pap. A. S. W., vol. I.—No. 2.

depend for their very existence on the distinctive force which they manifest, since they are decomposed into simpler compounds when vitality is destroyed. Again the potency of vital force as manifested among the higher compounds appears to vary, within certain limits, directly with their complexity; thus, in general, the tissues of living and moving animals are more complex chemically than the tissues of plants which live and do not move; the flowers and fruits in which the vitality of plant species resides are more complex in constitution than the woody stems and other structures of simpler function; the germ in a grain of wheat or corn is more complex chemically than the surrounding envelope from which the budding plant derives nutriment; and the animal brain, which not only lives and moves, but displays a wider range of activities and susceptibilities than any other known substance, is made up of the most highly complex compounds known to chemistry. So chemic constitution and vitality appear to be inter-dependent and at least in some degree correlative, and the living things of the earth live, move, perceive, and act according to the constitution of the earth-stuff of which their substance is made.

Like all other chemically complex substances, the compounds of carbon, hydrogen, oxygen, nitrogen, etc., which manifest vital force are highly susceptible to chemic action and reaction, and even to molecular and molar movements; *i. e.*, they are highly unstable. It is, indeed, this ready susceptibility to external forces and conditions that raises living matter above the plane of the inorganic. Moreover, the higher compounds are more unstable than the lower to the extent that they can exist only under delicately balanced chemic conditions, themselves depending on narrowly limited molecular conditions; thus, wood and ivory are decomposed by certain acids or by heat; the soft tissues of plants are broken down by more dilute acids or lower heat; the tissues of the higher animals break down under still weaker acid or still lower heat; and nerve matter is disorganized by a multitude of poisons, by changes of temperature running through only a few degrees, even by slight mechanical shock. Indeed, so delicate is the adjustment between living matter and the conditions by which it is environed that if the mean temperature of the earth were raised or lowered through only a few dozen degrees, the teeming life of air, water, and land would cease to exist; and if the heating or cooling extended through a few score, or, at the most, a few hundred degrees, every compound known to manifest vitality would be destroyed. This delicacy of adjustment between life and its environment is constantly to be remembered in considering the origin and history of living things. Astronomy and geology teach that the earth is a cooling body, and that it is only during the last stage in world growth—the stage covered or nearly covered by geologic history—that the temperature has been so far reduced as to permit living things, or even the unstable compounds of which they are composed, to exist on the earth. So,

while the unwritten history of the earth, running from primeval chaos to the age of man, is long and writ in many chapters, it is only in the last chapter that the record of life appears.

The dependence of life on chemic conditions and on temperature and other molecular conditions must limit its distribution in the cosmos. Thus, it is evident that living things such as those of our planet can not exist on the sun or other stellar bodies, for they are so hot as to decompose the unstable carbon-hydrogen-nitrogen compounds which alone manifest vital energy; nor can organisms like unto those of our earth inhabit the moon, for its temperature is so low that the vital fluids would be congealed; nor can life as we know it exist on the planet Jupiter, since he is almost certainly too hot, on the planet Mercury, since the daily temperature changes are almost certainly too great, or with any degree of probability on any other planet save possibly Mars, which may, perchance, be neither too hot nor too cold nor subject to so great temperature changes as to break up the unstable compounds of which living things are made. There may be other planets revolving about other suns so conditioned as to support life analogous to that of our earth, but if so, they are beyond the reach of the telescope, outside the ken of science; and it is of course possible, though not clearly conceivable to trained thought, that life may be manifested on other cosmic bodies by chemic compounds differing from, and under molecular conditions unlike unto those of our planet, just as it is possible, though not easily conceivable, that molten lead may be an agreeable beverage in some other part of the cosmos; but with such possibilities exact knowledge has nothing to do.

The exceeding susceptibility of living things to external forces and conditions gives meaning to the terms "vital force" and "vitality," which would seem to be nothing more than convenient and non-committal expressions for this susceptibility and its attendant reactions, and indeed Spencer has defined life as "The continuous adjustment of internal relations to external relations;" but since all known manifestations of vitality are conditioned on chemic constitution, which is in turn limited by temperature and other molecular conditions themselves depending on cosmic relation, it is evident that this definition is hardly so exact and so comprehensive as present knowledge requires; and life has been defined elsewhere as "The continuous adjustment of internal relations to external relations' among certain definite chemic compounds under certain molecular conditions determined by exceptional cosmic relations." Now, while this definition is not an explanation of the nature and development of living things, it suggests an hypothesis of life which may be enunciated as follows: (1) The known chemic compounds are more or less *unstable*, and in general their instability varies directly with their complexity. (2) The higher compounds are so unstable as to be incapable of existing save under an exceedingly narrow range of chemic and physical conditions; they are, therefore, in a

high degree *susceptible* to external forces and conditions. (3) The highly unstable compounds are sometimes unaffected, sometimes modified, sometimes destroyed by external forces and conditions; when those that are unaffected retain their primitive character and are thereby excluded from the category of the susceptible, and those that are destroyed disappear from the scene of cosmic activity in their original form, while those that are modified are thereby more delicately adjusted to the sum of external forces and conditions. (4) Through the exclusion of the insusceptible, destruction of the over-sensitive, and preservation of the delicately adjusted among the higher chemic compounds, resilience—or the capacity for internal reaction, or response to external forces and conditions may be developed gradually through that continuous transition which characterizes natural processes and which Powell has formulated as “The Law of Becoming.” (5) The responsive compounds are constantly coming into contact or collision with the external; when those that are not affected by the collisions retain their character and are thereby excluded from further progress, and those that are excessively affected are destroyed, while those that yield to or interact with the external are preserved and thereby brought into closer harmony with a wider range of cosmic forces and conditions; and this adjustment to the widest possible range of forces and conditions makes for the preservation of the compounds thus constituted. (6) Through the exclusion of the irresponsive, destruction of the over-responsive, and preservation of the duly responsive among the delicately adjusted higher chemic compounds, internal activity may be developed to such a degree that each contact with the external may initiate a long-continued series of internal movements, *i. e.*, a limited spontaneity may be developed. (7) While spontaneity might not directly tend to increase the probability of survival among—and thus might not prove directly beneficial to—highly unstable compounds, it would nevertheless accompany that delicacy of adjustment required for its survival (*e. g.*, perhaps, as functionless tactile sense accompanies the distinct special senses of the delicately constituted tongue and eye); and thus the endless succession of collisions characteristic of the cosmos would tend to exclude the non-spontaneous, eliminate the over-spontaneous, and preserve the duly spontaneous, and so make for the increase in spontaneity. (8) Despite their wide variety there is a certain rhythm in cosmic movements (*e. g.*, growing out of rotation and revolution in relation to other bodies) which imposes a certain degree of order on cosmic collisions; and those spontaneous compounds whose internal activities chance to accord with the external rhythm enjoy the greater probability of survival, and thus rhythmic interaction between the internal and the external may be developed. (9) Through the exclusion of the non-rhythmic, elimination of the ill-rhythmic, and preservation of the duly rhythmic among the spontaneous compounds, attunement to the external, or rhythmic spontaneity,

may gradually be developed through the continuous transition comprehended under the law of becoming. (10) That internal adjustment to subsequent external events, which attunement between the internal and the external involves, is directly beneficial to compounds possessing such constitution; and, as the attunement becomes more perfect and extends to successively wider ranges of external forces and conditions, the internal activities may eventually become such as are determined by past experiences, so that the faculty of prevision may be engendered; and prevision, or the prediction of the future in terms of the past, is the beginning and essence of consciousness.

It is to be noted that the unstable, susceptible, and responsive compounds and those manifesting both simple spontaneity and rhythmic spontaneity are modified—sometimes by few, sometimes by many, external forces and conditions; when those that are affected by few causes change slowly and retain long their primitive character, and are thereby excluded from the leading rank in adjustment to the sum of the external, while those that are affected by many causes are thereby brought into correspondence, or harmony, or accord, or congruity with the wider range of cosmic forces and conditions. Now, through the exclusion of the less congruous and the preservation of the more congruous, exceptionally responsive, and widely congruous, materials may be developed through a series of successive inter-actions between the substance and the environing forces and conditions, when the condition recognized in Spencer's definition of life will be fulfilled. Moreover, through the exclusion of those materials whose external activities represent immediate causes and the preservation of those whose internal activities represent remote causes, spontaneity, both simple and rhythmic, may be developed to such an extent as to be limited only by the persistence or durability of the material.

Thus, under this hypothesis of life, vitality includes susceptibility to external forces and conditions analogous to, if not identical with, that of the higher abiotic chemie compounds, together with response, through which the substances by which it is manifested are themselves modified, as well as a high degree of spontaneity, whereby long continued internal activity is secured and, sometimes, rhythmic inter-action between the internal and the external or prevision, which is the basis of consciousness, and also congruity with the forces and conditions of the cosmos. Accordingly, life may be defined as *the limitedly spontaneous inter-adjustment of internal and external relations between congruous substance and its environment*; or, more briefly, as *the spontaneous inter-adjustment of the congruous*.

In this hypothesis of vitality, it is assumed that the primary activities are simply those growing out of chemie action and physical inter-action; and it is assumed that the material or materials vitalized through long continued series of inter-adjustments are at the outset produced continuously by combination of contiguous lower compounds and ele-

ments, and this may have been the beginning of absorption or material growth, after a manner analogous to that of the growth of crystals. Thereby a vitalized self-perpetuating magma may have been produced wherever the chemic and physical conditions were favorable. Now it would appear that an essential antecedent condition for the production of such vitalized substances as those found in the waters and over the lands of the earth would be the presence of carbon, oxygen, nitrogen, hydrogen, and certain other elementary substances either free or in easily modified combinations. Several of these elements of the vital compounds are known to exist free or in readily combined or dissociated compounds at the present time; but it is singular that hydrogen is rarely found free in the modern earth, and indeed could hardly now exist on the terrestrial surface, since its specific gravity is so low that it would quickly be displaced by denser gases. This fact suggests that vitalized materials could not originate spontaneously under the existing cosmic conditions by which the earth is environed; and, while it is difficult to understand how this highly elastic gas was chained to the earth in its earlier stages, it seems on the whole probable that the life of the earth began, and could only have begun, about the period of transition from the planetary stage to the stage of geologic development. Accordingly it would appear probable that the course of life on the earth has run parallel with the differentiation of the terrestrial surface into oceans and continents, sea and land, mountain, valley, and plain.

While the above hypothesis explains the development of spontaneous inter-action, or of motility, in a vitalized magma, it does not directly explain the origin of reproduction nor the development of individuals and organization; but it readily suggests the supplementary explanation. The vitalized magma, whose persistence depended on adjustment to external forces and conditions, was constrained by gravity and thus limited in size; large masses were liable to break beneath their own weight and even the smaller were liable to disruption by impact against other masses. Now, those that were reduced to simpler chemic form in consequence of disruption were thereby destroyed and removed from the race for survival, while those that resisted decomposition were thereby the more delicately adjusted to their environment, and through this process of the destruction of the indivisible, and the preservation of the divisible, the capacity for division was developed; and such may have been the beginning of multiplication by fission, the simplest form of reproduction, to which all others may be traced. At first the chances of survival of the two parts of a body divided by fission may have been equal, and, judging from the analogy of the vast numbers of lower organisms destroyed through the struggle for existence, myriads of primitive bodies must have been divided and eventually destroyed in the endless succession of mechanical shocks characteristic of cosmic existence before a higher mode of reproduction was

developed; but whenever a body was of such size and such chemic constitution that when divided one of its parts chanced to be more delicately adjusted to environment than the other part, then (1) the more delicately adjusted part survived the longer, and (2) the parent body which divided unequally thereby secured an increased chance of perpetuating a part of its substance; and thus, by the destruction of bodies dividing equally and the preservation of the more highly developed portions of those dividing unequally, unequal division may have been developed, and the plane of vitality raised by the elimination of the lower and the conservation of the higher in individual bodies, and this may have been the beginning of reproduction by budding or by the formation of spores and the germ of organization. Accordingly the inter-adjustments growing out of chemic and mechanical action may be traced with unbroken continuity through the beginning of absorption or growth, the primitive stages of individuation, the simpler forms of reproduction, and the inception of organization, *i. e.*, to those characteristic vital processes common to the living things of the earth.

Thus the hypothesis explains the origin and development of those attributes of living things which are commonly regarded as primitive or fundamental, and moreover it explains the still more important though frequently neglected quality of heredity among the simplest forms of life. Under the hypothesis, heredity, or the persistence of primary characters, is in no way dependent on cell structure or any other feature of organization, but on chemic composition, and varies directly with the stability of the chemic compounds of which the bodies are composed and inversely with the susceptibility of the compounds to external forces and conditions, *i. e.*, to vitality. So it would appear that, in so far at least as bodily constitution is concerned, heredity is a primitive character, and that the degree of vitality, or the potency of life, culminates in the highest organisms; though the persistence of vitality, or the resistance of a body to dissolution, culminates among the simplest and lowest living things. This inference is in accord with the sum of knowledge concerning the organisms of the earth. The lowly slime-molds, which in one stage of their existence are undifferentiated protoplasm, maintain their specific purity more rigidly than any of the higher life forms, for, although the protoplasm-streams from the spores of two species may intermingle, each reproduces its kind with the highest exactitude; the Palæozoic brachiopods and corals lived through geologic ages, each made up of uncounted millenniums, without appreciable change in specific character, and each individual was the exact image of his fellows; in the later geologic ages the persistence of the species progressively diminished, and the diversity among individuals of the same species progressively increased; the prevailing species of to-day are constantly adjusting themselves to general environment, and the individuals of each species are constantly adjusting

themselves to local environment, so that this may justly be called the age of specific and individual variation, or the age of hybrids; indeed, in this last eon of the history of the earth heredity is so far subordinated to response and spontaneity that many animals and plants are no longer able unaided to perpetuate their kind, while the domesticated animals and cultivated plants have lost their original affinities and become the creatures of human craft. Accordingly life—which represents the highest susceptibility to external forces and conditions, the attunement of the creature to the harmony of the cosmos—buds in the zoöphyte, blooms brightly in the busy ant, the bounding antelope, and the soaring eagle, and burgeons gloriously in the active brain of man; and the potency and perfection of life, the value of vitality, increases progressively from the lowest to the highest among the living things of the earth.

In brief, life is a manifestation of force pertaining to certain highly complex and unstable compounds which have abounded on the earth during the ages recorded in geologic history, but which can not have existed during the earlier stages of planetary growth and can not exist to-day—except in a relatively minute part of the known cosmos; out of all the innumerable self-luminous suns that jewel the firmament, out of the seven great planets and the hundreds of asteroids that wheel about our sun, out of the score of satellites circling the planets of our solar system, out of all the myriad cosmic bodies within range of human vision, there is but one which is certainly so conditioned, and one or two more possibly so conditioned, as to permit the existence of vital compounds on their surfaces. Accordingly, the earth is not only the home of living things, but, so far as human knowledge extends, their only home.

The development of life.—The development of living things from the simple and lowly forms of the prime to the highly organized animals of the present is recorded in fossils and other organic remains in the rocks of the earth; and indeed, the rocks are classified by the records of past life entombed within them. In the present age of the earth, intelligent man prevails and events are recorded in written history; but the written record covers no more than a few thousand years, even in the oldest nations. Next beyond the historic age lies a shadowy and ill-defined pre-historic age, during which primitive man probably existed, and then follows the Cenozoic age of the geologist, the age of modern life, in which living creatures approached more or less closely to the modern forms, the animals being known from their bones, teeth, shells, and tracks, and the plants from their wood, leaves, and fruits preserved as fossils in the newer rock formations. Beyond the Cenozoic age falls the Mesozoic age, or age of middle life, whose rocks underlying the Cenozoic yield fossil remains of plants and animals simpler, cruder, more primitive than those of modern times; still further away from the present are the records of the Palæozoic age, or age of early life, in

which the living things were like unto the simplest and lowliest of the present, or even simpler or lower than any now existing, as shown by the fossils from the older rocks; while the earliest age with which the science of past life has to deal—the Agnotozoic age, or age of unknown life forms—yields but a meager and indefinite record of the beginning of organic existence.

Now, while the history of the development of life on the planet is too long and too elaborate for repetition here and while it is obscure in many portions, certain tendencies or laws are indicated within it which are worthy of special attention: At first the living things were apparently devoid of woody, stony, and bony structures, like the lowest plants and animals of later ages, and were probably akin to the monera and related creatures of the present, simple, ill-organized masses of protoplasm gradually assuming cell structure and an indefinite organization; their bodies probably consisted of relatively simple compounds of carbon, hydrogen, nitrogen, etc., as do the bodies of the amoebæ to day; their vital characteristics were probably limited to simple motility, irritability, metabolism, and heredity, as is the case with the simplest forms of life known to modern students; and it is probable that by far the most important of these characteristics was that which is frequently neglected in the consideration of early life, namely, heredity; and the beings themselves, like the relatively simple compounds of which they consisted, were probably far more stable, both individually and specifically, than their more highly organized progeny—so stable, indeed, that some of their kind have come down to the present with little modification. Such, doubtless, was the beginning of life on the earth, and the condition of life during at least a part of the Agnotozoic, though it is probable that higher life forms came into being before the end of the Agnotozoic and that their remains will some day be found in the form of fossils.

During the Palæozoic age—the age of early life—the living things differentiated into plants and animals, chiefly marine: for in that stage of world growth the oceans were greater and the lands were smaller than to day: The plants at first were simple seaweeds, but later they crept out of the waters on the growing land surfaces as forests of huge ferns, giant mosses, tree-like rushes, and other plant types similar to certain pigmy forms of to-day, though hundreds or thousands of times larger; the animals were at first mollusks, corals, crab-like trilobites, plant-like crinoids—the stone lilies of the primitive period—and sea-worms with stony or chitinous structures for shells and skeletons; but, later, vertebrates were developed and they and some other organisms pushed out on the land amidst the forests of ferns and mosses. During this age the organization of animals and plants increased greatly in complexity; at the same time the chemie compounds of which they were composed increased in complexity and the organisms diminished in stability, so that few of the plants and animals of that early day have come down to us in unchanged condition.

Spec. Pap. A. S. W., vol. I.—No. 2.

During the Mesozoic age, or age of middle life, the marine animals and plants differentiated and became more complex and unstable; but life came to prevail over the land and the dominant types breathed air rather than water. The four-footed beasts increased in number and in strength; flying insects began to buzz among the trees, and birds harbored in the forests; and the beetles fertilized those plants that began to bear flowers, and the birds distributed the seeds of those that began to bear fruits; and thus the plant life of the land was changed. During this age the organization of living things was still further perfected, and progressively more and more complex chemie compounds were probably produced by vital action; at the same time the stability of animals and vegetal forms diminished so that few of the Mesozoic types have come down to us, and the Mesozoic fossils are less useful for classification than those of the earlier ages by reason of their variability.

During the Cenozoic, life continued to prevail on the land, and insects, birds, and beasts became more and more differentiated; talons and beaks grew among the birds of prey, and teeth, tusks, and claws among the beasts; while the plant-eaters grew fleet and cunning and there was a marvellous increase in the volume of the animal brain. Throughout this age bodily organization became more elaborate, while the chemie complexity, at least of brain matter, increased, and the stability of the higher forms continued to diminish.

During the historic period and the immediately antecedent pre-historic age made known to us through archaeology, intelligence prevailed and man came to rule over the earth and to destroy or mold to his will the animals and plants; his brain is the most complex chemie compound known; and, while bodily variation in his kind seems to have ceased, his works and his institutions are constantly changing, ever for the better, so that this last short age is characterized by change more rapid than ever before in the history of the earth.

Thus the record of life on the earth runs from the ill-organized, chemically simple, and stable to the highly organized, chemically complex, and unstable among living things. The first age in the geologic history of the earth—the Agnatozoic—appears to have been one of simple, ill directed, unorganized, and feeble vital force, or of *vital magma*; the second, or Palaeozoic, was the age of *numbers* when living things increased to multitudes of species and myriads of individuals; the Mesozoic, or middle life, was the age of *might* when brute strength prevailed and the theatre of vital action was changed from the sea to the land; the Cenozoic was the age of *activity* displayed first in fleetness and then in cunning, gradually growing into intelligence; while the present is the age of *mind*, in which organic development culminates in brain structure, while brain work controls the world.

So the history of past life on the earth pictures with marvellous clearness the relations among the living things of to-day, of which most are belated survivors from earlier ages and only a few with man at

their head, are really representative of the age of mind; the undirected or ill directed vital force of the beginning gave way to numbers of individuals, the numbers fell before individual might, brute force bowed before activity, and bodily activity has yielded to intelligence. The story of life on the earth is the grandest epic inscribed in the book of nature; and the record of man's place at the head of all other earthly things is its grandest canto.

The hundred of men.—In the beginning of biology, human knowledge was a chaos of isolated facts concerning living things whose relations were not perceived; in a later stage the living things were grouped in a hierarchy or orderly system of species, genera, families, and orders, which were recognized as running from the lowly and simple to the higher and more complex, and this arrangement was interpreted as the expression of a preternatural and admirable plan, and a long line of high priests of the gospel of special creation, ending with Agassiz and Dawson, extolled the wonderful works of the Creator. Then came Spencer, Darwin, and Wallace with the doctrine of evolution, and it was perceived that living things represent not simply a hierarchy running from the low to the high, but a genetic series, in which the higher sprang from the lower through the operation of natural forces and conditions implanted in the cosmos at the beginning, and thus residing in the earth; and thereby a new and nobler plan of creation was recognized, and the modern high priests extol a more exalted theme than the old.

Under the doctrine of evolution, the relations of the living things on the earth may be shown like the relations of individuals in a family group by a kind of genealogic tree whose numerous and widely diverging branches may be traced down to the primary stock. The stock of the tree of life on the earth stands for the simple life forms of the Agnæozoic when terrestrial vitality was represented by ill organized forces, and the stock divides upward with the development, multiplication, and differentiation of organisms; yet, like the trunk of the elm or oak, the original stem rises through the ages to the present and is represented by the existing uncebboid forms and protoplasmic stages. One of the great branches springing from this trunk is represented by the animals of radiate structure, such as the crinoids and sea urchins, and this, like other great branches, is subdivided into many branchlets and twigs; another great branch is represented by the articulated animals with external chitinous or stony skeletons; and the most important branch, which is closely allied to that of articulates, is represented by animals with internal bony skeletons. The most important branchlet of this great branch is that of the mammalia; and most conspicuous among its twigs is that representing the animals with hands. Some there are indeed who question whether the mammalian branchlet of the vertebrate branch of the tree, or indeed any part thereof, supports the crowning glory of terrestrial vitality, the human organism; but the no-

tion that man is not a member of the earth's great family of living things has long been subsiding and must be finally set aside.

It is now a generation since Darwin showed that not only are the bones, muscles, nerves, and other organs of the lower animals essentially similar to those of man, but that there are found in the human body certain rudimentary organs—or vestigial organs, to use the more acceptable term proposed by Riley—which are without function and whose presence can be explained only on the hypothesis of descent from simian or pithecoïd, (*i. e.*, ape like or monkey-like) ancestors to whom these organs were of use; and about the same time Huxley showed that, when anatomical characters, particularly those of the brain and its receptacle, are compared, it is found that certain savages and idiots and other men of low development more closely resemble the higher apes than the higher representatives of the human species; in other words, that there is no anatomical break between man and the apes. Not long afterward Haeckel and others pointed out that the human embryo is undistinguishable from the embryos of the lower vertebrates and that in its gradual development into the human form it passes through successive stages of homology with reptilian, avian, and mammalian embryos, thus repeating in epitome the history of development previously inferred from anatomical characters; *i. e.*, the embryotic development of the human individual is inexplicable except on the hypothesis that man has come up from a lower estate and is thus the crowning glory of a long line of less noble ancestry. These demonstrations have sufficed to convince nearly all biologists that the human species (*Homo sapiens*) is genetically related to the anthropoid apes and through them to every part of the genetic series of terrestrial life. But each new discovery yields a higher point of view for further research into the undiscovered, and thus the progress of knowledge is cumulative; and recent researches in psychology, based on the evolution of human characteristics, appear to yield new and absolutely conclusive proofs of man's ascent from a line of lower ancestry to his present condition.

As explained by Powell in his system of psychology and as specifically indicated in the foregoing hypothesis of vitality, mental action or mentation is the manifestation or product of inter action between highly organized nerve substance and external forces. Now, the responsivity of nerve matter, which is the most highly complex and unstable among terrestrial compounds, would seem to be the outcome of a long course of development in which the irresponsive was destroyed and the highly responsive preserved; and, the final effect on the highly sensitive nerve matter of each collision between that matter and the external world being determined in large part by previous collisions, the character of each nerve reaction may be considered the resultant of all the inter-actions in the long course of physical development of which nerve matter is the fruit. Thus mentation would appear to be a link in the

chain of inter adjustments constituting vitality, and that in which internal reaction or spontaneity is most perfectly developed.

Now, under this system of psychology, intellectual development must have been exceedingly slow; and while, like other natural processes, it must progress cumulatively with each new inter action, as the structure of the nerve matter comes nearly and still more nearly into accord with its surroundings, still a vast period must have been required for the development of the higher grade of brain structure and the mentation characteristic of the age of intellect in the history of the earth. Moreover, the process of development must have been marked by certain stages coinciding with those actually displayed among the lower living things of the earth and displayed still more clearly among the lower living things of past geologic ages brought to our knowledge through paleontology. Thus, under Powell's system of psychology, which is by far the most satisfactory thus far formulated, the human brain is but the keystone of an arch rising through the lower organisms of earlier eons, the product of myriads of inter actions and reactions covering the greater part of the period of life on the earth.

Under the Powellian psychology there is an embryology of the mind as well as of the body, and the mental development of the human infant is thus an epitome of the mental development not simply of the race, but of mankind, and even of the long series of lower and ever lower ancestors revealed as the scroll of world history is rolled backward.

Furthermore, under this system of psychology the intelligence of the world is essentially alike, differing perhaps in degree of development, but never in kind; always representing inter action and revived action between highly organized nerve matter—chemically complex and unstable matter, which alone manifests, and which never exists without manifesting, this kind of activity—and external bodies or forms, whatever the degree of development of the organisms possessing it; and that which the hypothesis requires is found to be true among the living things of the earth. The intellect of man is similar in kind to that of domestic animals though higher in degree, and intelligence is conveyed to and received from the horse, the dog, the cow, and all other domestic animals; and when civilized man comes into contact with savage man or wild animals, the two grades of intellect are either mutually adjusted or the weaker is overcome. Moreover, the trend of intellectual action, the aim of intellectual organisms, is always alike: the intellect is the servant of the organism and seeks to protect and benefit its master through the conquest of natural forces and conditions. By reason of intellect, men build houses to protect themselves from enemies and the elements—so do birds, musk rats, and beavers; by reason of intellect, men hoard food—so do bees and squirrels; by reason of intellect, albeit hardly the highest, men enslave their kind—so do ants; by reason of intellect, men lay snares for game—so do spiders; by reason of in-

tellect, men plant and cultivate and afterward harvest—so, it is believed, do the ants of the southern plains; by reason of intellect, men band themselves together for mutual protection—so do birds and beasts on land and fishes in the sea; by reason of intellect, men arrogate unto themselves proprietary rights to certain land, and protect their domains against trespass—so, in somewhat less degree, do those carnivorous animals who establish and protect and mutually respect their ranges; and in many other ways the unity of mental action by men, lower mammals, cold-blooded vertebrates, and even the lowly articulates is displayed. It is indeed significant that the highest intellectual development among the living things of the globe seems to be reached in the widely diverging branches of the genealogic tree represented respectively by man among the vertebrates and the ant and the bee among the articulates, for thereby kinship among all living things is shown more clearly than by anatomic relations.

Thus the living things of the modern earth and all of their multifarious ancestry must be conceived to represent a single family bound together not simply by external resemblances and superficial affinities, but by blood relation. The way was long, very long, and very difficult from the beginning of responsivity in the highly complex compounds of the prime to the differentiation of even the lowest among the living things like the amœbas, and untold myriads on myriads of unorganized masses of differentiating matter fell by the wayside; the way was very long and hard from the simple mass of responsive matter capable only of perpetuating itself by absorption and reproducing its kind by fission to the development of simple organization, and myriads of the ill organized bodies fell out of the race; the way was long and devious from the beginning of definite organization to the development of individual might, when brute strength came to prevail, and the rocks of the earth are charged with the remains of the imperfectly organized beings that failed of this goal; the way was rugged from brute strength to activity and cunning whereby living things escaped their foes and fled the elements, and the wayside was strewn with the bodies of the ungainly and the stupid; the way was steep and dark from the activity of fleetness and cunning of the beasts to the comprehensive human intelligence that enslaves animal foes, imprisons fire, and chains the lightning, and in other ways molds the earth to his liking, and the weaker-minded were dazed or lost and left behind; but all these ways of progress join or overlap and through them all has man come to his resplendent castle on the crest of the delectable mountains.

The antiquity of man.—No definite record has yet been found of the beginning of human existence on the earth. Written history runs back into the haze of legend and ends in the shadow of myth at 5,000 or 6,000 years ago; but man was then a thinking, speaking, and writing man like the higher barbarians of to-day. Certain chronologic periods

based on astronomic observation indicate that the positions of the moon, sun, and stars, have been observed and recorded or remembered throughout a period extending over 10,000 or 20,000 years; but these chronological eras tell of men like modern barbarians, and not of the infancy of the race. The differentiation of language records a vast period, which has been estimated by philologists at not less than 20,000 years; but at its beginning man was a speaking animal like modern savages, and not the humbler prototype of the human species. So the indications of human antiquity found in the direct products of intelligence would seem to carry the beginning of the race at least 10,000 or 20,000 years or perhaps twice as long into the past.

The geologic evidence of human antiquity is more definite than that yielded by history, written, legendary, and inferred, save that it is not easily reducible to years: A potsherd has been found in the Nile delta overlain by the silt layers (partly counted, partly estimated) of 15,000 annual floods; but, while this relic unquestionably antedates the oldest pyramids, it represents the work of a pottery maker, as well advanced in the arts as modern savages. Caves and valley gravels of Europe have yielded human bones and works of art indicating the existence of man during and probably before the close of the glacial period, at least in its closing episodes, and the last ice invasion is estimated to have occurred from 7,000 to 50,000 years or more ago; but even then man was in all probability so far developed as to be certainly assignable to the existing species of *Homo sapiens* and had mastered rude arts akin to those of modern savages. The river gravels of this country have been supposed to yield evidence of glacial man, though recent researches, chiefly by our gifted contemporary, Holmes, have shown that the evidence is not conclusive; yet even here there are geologic indications of considerable human antiquity, through the earliest records are of a stone-shaping and fire-using man, and not of a pre-human ancestral form. In many cases the earlier human relics are associated with the remains of animals now extinct or displaced to other areas, of which a considerable number belong to a fauna commonly assigned to the early Pleistocene or the late Tertiary; yet it is to be remembered that the earliest records of human existence tell not of the very beginning of mankind, but of a human form intermediate between modern savages and the higher simians, and more nearly related to man than to any lower form.

THE APOTHEOSIS OF NATURE.

The work of living things.—The living things which abound in the waters and in the air depend directly or indirectly on the earth for support; but at the same time they react on the waters, the land, and the air and thereby modify these elements, and thus the character of the earth itself. So the earth is no longer a dying planet made up of simple minerals, but a highly complex body whose superficial portion

represents the joint product of vital, chemical, and physical agencies.

The simple and lowly life-forms of the prime spent their force in assimilating the higher chemie compounds corresponding more or less closely in composition to their own substance; and by virtue of their capacity for assimilation they grew and increased and consumed great quantities of fitly constituted matter and produced great quantities of compounds somewhat higher in the scale of chemie differentiation than those previously existing; and this was the beginning of the transformation of the earth through the agency of living things. So the rocks of the Agnotozoic age, which form some lands of the earth and gave rise to the sediments which formed lands of later birth, are made up in part of biotic compounds, of substances bearing the impress of the action of living things in their composition.

As the chaotic vital force of the beginning assumed a definite direction the living things of the earth increased marvellously in numbers, and at least during some ages and in some parts of the world the seas swarmed with radiates, articulates, and mollusks, as well as lower and simpler organisms; and as time passed some radiates built for themselves stony structures, some articulates developed chitinous frames, and some mollusks secreted semi stony shells, while certain lower organisms consumed mechanical sediments and transformed them into chemie precipitates; and in this way it is probable that the waters of the ocean were modified and certainly the sediments of the ocean bottom came to be made up in considerable part of the remains of organisms and of complex compounds produced by organic action; and thus the transformation of the earth by living things was carried forward.

As life waxed the endless contest for survival and supremacy among the living things of the earth grew fierce and progressively higher forms were developed. The simple plants of the sea pushed out on the growing land, and in the growth and decay of successive generations transformed the barren rocks into fertile soils made up in part of their own remains and in part of the compounds which they generated. While some of the simple animals of the sea retained their primitive forms, others developed bony armors supported by bony skeletons, and were thereby more perfectly adjusted to their environment, and some dominated the sea, while others pushed out over the land and foraged on the land plants or devoured each other. This was the age of individual might, during which the lower organisms continued to consume and transform simpler chemie compounds, while the higher consumed the lower and raised their composition to still higher grades of complexity, and in this way the lands and the air above the lands, as well as the sea, came to be affected by vital action. Thus the transformation of the earth through the agency of living things was carried forward with ever-increasing rapidity.

As the earth grew old, and the seas shrank, and the continents widened, and as snow and ice gathered about the poles and on the

mountains, the ceaseless struggle for existence among living things raised vitality to a higher plane, and cunning came to prevail over the land and to some extent in the sea; the transformation of lower compounds and lower organisms through consumption by the higher continued, and sea animals and plants pushed up into the rivers and lakes, and after accustoming themselves to sweet waters continued to transform crude earth matter and in turn to supply sustenance to their more exalted foes on the land; meanwhile insects began to fertilize plants and the flora was thereby made to support a more abundant fauna; and insects, birds, and beasts learned to seek or construct shelters from the inclemency of the weather on the ageing earth and thereby to prolong their lives; and thus the transformation of the inorganic earth continued cumulatively, the change of each age being more varied and more rapid than that of the period before.

So the history of the earth from the earliest geologic ages to the advent of man and the beginning of intellect is one of progressing and ever increasing transformation of the materials of the earth; and this process has now gone so far that there are probably no terrestrial materials known to man which have not been modified by vital action, save, possibly, a few ancient crystalline rocks and a few lavas from the deeper sources. Moreover, the history is one of progressively increasing utilization of cosmic forces. Plants and animals are stimulated by light and heat and through these stimuli their activity is multiplied if not generated. Vitality is the flower of the plant which buds in chemie affinity, so that the force of chemism is utilized by all living things. Intellect and cunning, like simple sense-perception, depend on interaction between bodily substance and environment, and thus every act of organisms in every stage of sense-development is a utilization and transformation of cosmic force. Thus, the external earth, the home of man, is the product of long continued vital action, the creature of living things.

The solidarity of life.—Just as the living things of the earth represent a continuous series in which the higher is developed from the lower and in which all are bound together by blood connection, so they represent a mutually inter dependent series in which few—if any—members could maintain separate existence. The seeds sown on bare rocks can not bring forth plants—they require a soil representing the product of previous plant generations and sometimes the aid of micro organisms. Even the highest animal—man—perishes when lost in the forest; he can not live without the fire which he has enslaved, the tools which he has made, the lower animals which he has domesticated, the higher plants which he has created by cultivation, hardly without the aid of his kind. In like manner many of the lower organisms depend on the higher; and in the end all living things appear to owe their origin to a primary vitalized magma developed through a peculiar combination of

chemic substances when the condition of the planet was unlike the condition of to-day. So the various living things of the globe, from the lowest to the highest, are inter-dependent.

In so far as living organisms are inter dependent they re-act on each other and each is modified by its neighbors. Through natural selection and the survival of the fittest in the constant inter-action of vitality, the bee carries pollen from blossom to blossom, whereby the clover is fertilized and made more vigorous, and yields more honey to tempt the bee, and thus the clover is gradually made a honey-yielding plant and the bee a honey-collecting insect, and each gradually modifies the other: the squirrel gathers nuts and hides them in the earth, where some sprout and grow, and thus promotes nut-bearing, and in his search for nuts develops characteristic organs and instincts which increase his chances of survival, and thus the squirrel and the tree co-operate and each modifies the other through a long series of successive inter actions; and in an endless variety of other ways the living things of the earth inter-act and each modifies the other. So no living thing lives unto himself alone, but each aids or injures his neighbors in an endless succession of inter-actions, and the entire series of living things of the earth is bound together in a single solidarity, and this solidarity of life is the glory of the earth.

The supremacy of man.—The beginning of conquest.—With the advent of man, bestial cunning gave way before intellect, but at the same time bodily organization rose to its highest perfection. It is probable that the supremacy of the human prototype sprang in part from the strength, activity, and adaptability in which the human body rises above the bodies of all other animals. The average man can outrun the average horse in a month, and the trained pedestrian outruns the Arabian courser in a day. The Chinese coolie and Canadian packer bear thrice the loads, in proportion to their weight, that can be borne by oxen. The savage can outclimb the baboon of equal weight, and the civilized sailor can outclimb the savage. The human animal is omnivorous, feeding alike on flesh, fish, and fruit, while the diet of most other animals is limited, and, in addition, the upright posture, the well-developed hands, and powerful arms of the human animal give him immeasurable advantages over the beasts. So mankind may well have risen above other living things in part because of bodily superiority, because the earliest representatives of his type could run, leap, climb, swim, bear burdens, grasp and throw better than their competitors in the struggle for existence. The great superiority of animal man to all other animals is one of the most impressive facts of biology. A few other animals, indeed, exceed him in certain directions, but he competes with all and exceeds most in every direction of bodily exercise, in every physical function, and the perfection of animal development is thus attained in the human body.

It is possible, if not probable, that the second step toward human domination of the lower world was the discovery and control of fire. Beasts, birds, and insects, build houses, hoard food supplies, lay snares for game, plant and cultivate certainly through instinct and probably through design, and in other ways seek to overcome nature and lift themselves above their environment; but man alone uses fire to protect life and secure comfort, prepare food, take game, and, generally in the subjection of nature; so that man may be distinguished, perhaps more justly than any other way, as the fire-using animal.

An early step in human development was the use of rude implements and weapons, at first, perhaps, after the manner of the apes in cracking nuts, and of monkeys in casting missiles; and thereby through the law of development by action, which is an example of the more general law of inter-adjustment between the organism and the environment, the muscles were taught, the eye was trained, and the various bodily and mental faculties were co-ordinated. While the beginning of stone-working is not definitely known by reason of the imperfection of the archaeological record, it would seem to have come up gradually by successive minute increments under the Law of Becoming from the use of natural pebbles and naturally broken rock fragments; and as shown by our American archaeologists, Holmes and McGuire, one of the earliest forms of stone work must have been simple bruising or pecking related to that produced accidentally in cracking nuts or crushing grain. Certain it is that less initial knowledge and skill are required for stone-pecking than for stone flaking. Moreover, stone pecking is produced by downward and inward blows, *i. e.*, by centripetal muscular movements analogous to those characteristic of all lower animals, of the lower races of man, and of the lower individuals among the higher races; while chipping and flaking represent outward blows, or strokes away from the individual, or centrifugal muscular movements such as are not known among the handless animals, rarely found among the four-handed apes and monkeys, uncommon among the lower races of men, and characteristic only of those above the lowest intellectual ranks among the higher races. Thus the earliest industrial arts appear to be those acquired in common by man and his higher four-handed kindred; they appear to have grown up through stone pecking, which is within the reach of apes and monkeys, to the highest grade of stone flaking and chipping, which involves manual skill little lower than that required in diamond cutting, gold beating, throwing a thread in a lathe, or file-cutting, the most highly developed operations of enlightened mechanics.

So by bodily strength and skill, by the control of fire, by the development of rude arts borrowed from the higher brasts, and by the training of hand and eye, and the co-ordination of faculties through primitive industries, mankind began the conquest of nature and entered upon a career which has already half transformed the face of the earth.

The conquest of plants.—The savage men of modern times subsist in part on the products of the chase, in part on fruits, nuts, and seeds, and it is probable that primitive men subsisted in a similar way. The higher savages gather and store vegetal products, and barbarous peoples plant hoarded seeds and thereby obtain larger and more certain supplies, and some cultivate the growing plants. In this way certain plants of the earth have been transformed: Wheat, oats, barley, rice, and corn, among the grains; the potato, parsnip, carrot, and several other vegetables of field and garden, and many fruits and berries, together with a number of grasses, have been so far changed by cultivation that they can hardly be traced to their original specific forms; and moreover their original habits of life have been so far transformed that they can not live without human aid: if man were to disappear from the earth, those grains, fruits, and vegetables which he has made to meet his needs could not hold their own in the struggle for existence, but would be swept from the face of the land within a few years. Thus these useful plants are not the creation of natural forces under a natural environment, but are the creatures of mankind, and reflect human needs, human industries, human purposes, human craft.

Certain plants, including different kinds of trees, are useful to man in their natural condition, and these have been preserved; certain other plants are useless or injurious, and these are gradually extirpated or displaced. Now, the process of extermination of useless and injurious plants has been curiously complicated. The primitive tiller of the soil sought to bring his crop to perfection with a minimum expenditure of labor, and at first abandoned and afterwards laid fallow fields overrun by useless plants, or weeds; then he adopted imperfect methods of cultivation, which resulted in the extermination of the weaker individuals among the weeds, and the preservation of the stronger; and thus unconsciously he cultivated useless plants more efficaciously than the useful plants until his fields came to be ridden with weeds; and even yet few farmers realize that there is but one way of coping with weeds, *i. e.*, total extermination, and that any less rigid process only increases their vitality, persistence, and pertinacity. But despite this complexity by which the ridding of the world of useless and injurious plants was hindered, the conquest of the plant world has proceeded with ever increasing rapidity; and in many regions only those plants are permitted to grow and yield fruit or substance which make for human welfare or pleasure.

Accordingly the conquest of the plant world by human ingenuity is well under way; the prevailing plants of the earth to-day are those which man has molded to his own liking; of which indeed the seeds were natural, but which he has none the less made, through a long series of operations under the Law of Becoming; certain other plants are preserved by reason of their utility or beauty in natural condition, but the useless and injurious are disappearing from the face of the earth, and the future flora will be the handiwork of man.

The conquest of the lower animals.—At first the hand of man was against all other animals, but as his budding intellect expanded and he recognized his superiority he began to capture his ancient enemies for pets and servants, thus reaching the intellectual plane of the ant, which enslaves its kind and keeps kine (in the form of aphides) for their milk; and this was the beginning of the domestication of animals. Before the beginning of written history the cat was kept as a pet, the dog as a companion and slave, the horse and camel as beasts of burden, the cow and sheep as sources of food, and the latter to supply clothing. In early times among barbarous peoples, fowls were kept for their eggs, feathers, and flesh, and the cormorant was trained to take fish and the falcon to capture wild fowls; the elephant was trained as a draft animal or to bear heavy burdens; and in like manner the bee was kept for honey and the silkworm for fiber. Thus a variety of animals were enslaved by man and made to contribute to human welfare and pleasure.

The enslaved animals were modified in various ways: The cat was kept for beauty and docility, and these qualities were cultivated, and thereby the animal was made one of the most beautiful yet cruel, and one of the most docile yet stupid, among the higher animals. The dog was bred for a variety of uses of which many required intelligence, and was thereby made one of the most variable and one of the most intelligent among animals. The cow was bred for flesh, skin, milk, and strength, and has come to yield rich returns in all these products of vitality, but remains one of the most stupid of beasts. The horse was bred for strength, speed, and intelligent responsivity to human will, and has become a noble animal whose neck is clothed with thunder and whose nostrils scent the battle from afar. He has developed a curious intelligence more readily inter-communicable with that of his master than is found in any other animal, mixed with a curious stupidity which renders him a helpless stayerling unless he is shod with iron and has carefully prepared food laid before him. The sheep was bred for its flesh or milk, and sometimes for its skin but chiefly for its wool, and has become extraordinarily modified, so that its force is expended in the support of a pilage which has grown into one of the principal sources of dress stuffs of the world; but its intelligence has not been cultivated and it remains timorous, helpless, and hopelessly stupid. The fowl was bred for flesh and eggs and sometimes for feathers, and its flesh has been made palatable and its fertility in eggs has been made one of the most marvellous monstrosities of biology; its feathers have been made to imitate the colors of the rainbow, but its intelligence has been neglected and it remains the incarnation of stupidity. In all these cases and some others the animals have been so completely modified through human instrumentality that their original specific relations can not be traced: in character, in mode of life, in function, they are unlike unto species developed under natural conditions.

In the development of domesticated species man has given heed to his own needs and not to the needs of his four-footed and winged slaves, and thus the characters of his servitors are abnormal if not injurious to the organisms, considered as representatives of animal life. The horse, sheep, and fowl have been made helpless to the extent that they would quickly become extinct without human aid; the cow of civilization, although more self-reliant, could hardly exist without the plants which man has cultivated. Even the dog and cat, the least changed and the most independent of man's four-footed servitors, would find themselves handicapped in the struggle for existence by most of the characters which man has impressed upon them, if mankind were to become extinct. Thus the development of animal characters under domestication is useful not to the species themselves, but only to man.

While a few animals have been enslaved and domesticated for his use, man has looked upon most lower animals as enemies to be destroyed either in the blood-thirsty wantonness born of generations of self-defense or as sources of food, and thus the primitive pre-human or infra-human fauna of the earth is melting away. The stealthy tiger and the kingly lion have been robbed of their domain; the noble buffalo faded at civilization's dawn like frost before the sun; the days of the elephant are numbered unless, indeed, he be preserved by domestication. Men of middle age now living have seen millions of passenger pigeons in single flocks, and hundreds of flocks in a week, but to-day there are hardly enough left to supply the demands of museums; and scores of other species have been exterminated within the period of written history. Thus, in the subjugation of the animals of the earth, men preserve only those that can be enslaved, and all others are slain.

The end of the conquest of the lower animals is not yet, but may easily be foreseen. Man has taken and is yet taking certain animals and molding them to his needs, completely transforming them, creating them according to his will, and all others he is destroying at an ever-increasing rate. The beasts of the pre-human period are disappearing through transformation and through slaughter, and at no distant day the only lower animals of considerable size remaining on the land will be those of human making, literally the creatures of human craft.

The conquest of the under-world.—At first savage men gathered rude pebbles from the brooksides for missiles and for use in cracking nuts and bruising food stuffs; later the pebbles were shaped into rude weapons and implements; and still later fitter rocks were sought in gravel beds, and eventually in the parent ledges of the hill-sides; and this was the beginning of quarrying and mining.

In a later stage of development copper was extracted and beaten into knives, spear-heads, arrow-points, and ornaments for the person; still later iron was collected and wrought. Perhaps the first iron to be used was meteoric, but subsequently ores were gathered from the earth and reduced in crude forges and furnaces, and iron, copper, brass, and

bronze were fabricated and used for an ever increasing variety of utensils, weapons, and implements; and this was the beginning of metallurgy.

At first the fuels were wood, and charcoal made therefrom; but later coal was found, and the work of extracting it from the earth was organized; and with the extraction of coal more varied implements were required, and the use of coal facilitated the fabrication of the metals; and thus coal mining and the extraction and reduction of metals interacted and industries were transformed cumulatively; and so manufacture began.

Primitive men delighted in personal ornaments, and adorned their ears, lips, arms, ankles, and garments with gewgaws. As time passed, and the conquest of the under-world through human ingenuity proceeded, ornaments came to be made of precious metals and gems, and the gewgaws grew into jewelry. So the collection of precious metals and precious stones became an industry, and with the development of proprietary conceptions which grew up with industries, these materials and the articles made therefrom came to possess a special value in the eyes of men and eventually became media of exchange. Thus the search for precious metals and gems was stimulated and commerce was facilitated and industries were developed to the extent that the movements of population and the spread of industries came to be affected by the thirst for gold.

Accordingly, the milestones in the way from savagery to enlightenment are represented by quarries, by the ore beds of iron and other useful metals, by coal mines, and by gold diggings; but the conquest of each new substance of the under world gave a new vantage point for further conquest, and thus quarrying and mining, industrial development, and intellectual grasp have interacted, each aiding the other, so that progress has been cumulative, and is now under way more rapidly than ever before, and with ever increasing rapidity. To day nearly all structural materials used in the building of our domiciles and factories, the fuels that transform summer into winter and winter into summer, the illuminants that turn night into day and thus lengthen life, the engines of locomotion on sea and land which unite races and peoples, the media of exchange which bind mankind into a homogeneous mass, are all derived from the under world, and thereby the condition of man and the face of the earth have been transformed. And within recent years perfumes and flavors like unto those of plants and fruits are derived from the rocks, and one of the most brilliant promises of science is the indication that at no distant day the ingenuity born of earlier conquest will enable men to extract the flower as well as the perfume, the fruit as well as the flavor, from the under world, so that food may be taken directly from the earth without the intervention of plants and animals.

The conquest of the microcosm.—The most abundant numerically, if not in aggregate volume, among the living things of the earth are the minute organisms of simple structure whose existence can be determined only by means of the high powers of the microscope, or sometimes by their effects on larger organisms. These bacteria are of many varieties, of which most are innocent or useful to the higher organisms, though a few are injurious. Like the higher organisms they are delicately adjusted to their environment, organic as well as inorganic, and thus belong to the great solidarity of living things. During recent years it has been ascertained that the noxious bacteria are causes of disease and death, and the science of bacteria—bacteriology—has been developed for the purpose of controlling or eradicating the maleficent microbes; for thus far the beneficent micro-organisms are commonly neglected in the study of bacteriology. The science of medicine has already been half transformed, half lifted from the plane of empiricism to the plane of exact science; already the plague of old has lost half its terrors and smallpox is under control; cholera is now engaged in its last struggle against human ingenuity and intellect, and many other diseases have been mastered, so that human life is prolonged. So the subjugation of the microcosm, the latest in the series of conquests which anthropology has to record and extol, is well advanced; and the promise for the future is brilliant.

The conquest of the land.—At first the land—like the air and the waters—was common to all living things except in so far as might made right and the stronger displaced the weaker; then men came to dominate over his animal foes and to claim small parts of the earth as his own; and this was the beginning of landed property.

With the multiplication of men and the birth of new industries the property conception was strengthened and the earth came to be parted into kingdoms and fiefs, countries and fields, and still later mining and milling rights grew into existence by a succession of minute increments acting under the Law of Becoming; for this is the mode of cosmic evolution which constrains mankind as well as lower organisms and the inorganic world.

With each discovery of new resources, with each invention or a new mode of conquest, the property conception was strengthened and various institutions came into being; and with each new discovery, each new invention, each higher institution, progress was facilitated so that the conquest of the land, of the plants it yields and the animals it supports, and of the under-earth beneath, is well under way. About one-tenth of all the lands of the earth are now appropriated to human use for fields and domiciles, factories, and highways, and no plants or animals are permitted to remain therein that do not subserve human needs; some three-tenths more of the lands of the earth, with all things pertaining thereto, are more or less perfectly appropriated to human use; and almost all of the remainder, save the mountain tops and the

ice-burdened poles, have become tributary to human needs and pleasures. Moreover, the rivers are bridged, the wilderness is invaded by highways, the deserts are traversed by lines of steel, all inhabited lands are bound into unity by message-bearing wires, while the locomotive annihilates ex-pace and the telegraph annihilates time. So human life is prolonged, and progress is promoted more and more successfully every year. Already the conquest of the land has progressed so far that he who will may laugh at the cold, scold at the storms, and enjoy the products of every part of the earth in whatsoever part thereof he may elect to stay. So completely, indeed, has man modified the land, and so far has the modified land reacted upon him, that mankind has become his own creature, fitted to civilized life—the highest form of existence ever attained—and no longer adapted to lower conditions. So man has partly made the land, the land has partly made man, and the two great factors in the later development of the earth have interacted cumulatively until each may justly be considered creatures of intelligence, the highest known force of the cosmos.

The conquest of the waters.—Primitive men, like modern savages, sometimes rode on floating logs, and thus caught the spirit of navigation. Then logs were bound by withes and rafting was developed, and thereby the spirit of navigation waxed. As the spirit grew the skill increased: logs were hollowed out by fire and cutting tools, paddles were first improvised and then made, and canoeing was developed. At length the ambition of the primitive navigators outgrew their simple craft of single logs, and the Norsemen and other maritime peoples built larger vessels of many timbers and invented oars, and thus boating began. As ambition and knowledge increased by minute increments under the Law of *Becoming* the boats pushed out farther and farther from shore and into deeper and deeper waters, and fiercer and fiercer storms were outlived. Long afterward the mariner's compass was invented, and then the stars were studied to the end that the mariner might find his place in the limitless ocean, and so gradually the waters of the earth came to be navigated in all directions. Thus the vitality of the earth, which began in the waters and afterward spread to the land and there attained its highest development, returned to make conquest of the seas, and shipping is now so perfected that the mariner scorns the storm, and seldom falls before its fury.

Even before the advent of man, land animals hunted along the banks of the rivers and shores of the seas that they might find fishes and other aquatic things; and man followed the example of his forefathers and became a fisherman. At first he was fain to confine his operations to brooks and the smaller rivers and peaceful shores; but with the growth of navigation he pushed farther and farther into the deeps, taking all sorts of fishes for food, pearls to ornament his person and serve as media of exchange, oils to keep his lamps alight, and a great variety of other commodities; and to day a considerable propor-

tion of the food of mankind is drawn from the waters of the rivers, lakes, and seas. At first man, like the lower animals, was content to take the fish wheresoever they were led by their own devices under the feeble intellect which burned in their ill-developed brains; but gradually fishermen came to realize the need of protecting fishes that the fisheries might be maintained; and still later enlightened men, stimulated by the analogy of the domestication of the land animals, perceived that aquatic organism may be selected and developed so that the rivers, lakes and seas, like the land, may be transformed into sources of food and other useful products. Thus the fisheries of the world are undergoing a change; already the supply of food obtained from the waters has been greatly increased and improved, and the increase and improvement are progressing cumulatively at a rapidly growing rate as the years go by.

Primitive man, like the beasts, went to the water-sides to find drink and to obtain the products of fertile and humid soils; but as his intellect budded, bloomed and bore fruit in new conquests over nature, he dug wells, opened canals, constructed race-ways and diverted rivers; and in this way a part of the waters of the earth have been brought to those places in which they best subserve the human interest and most fully promote human happiness. Even before the dawn of history irrigation was practiced, as is known from the ruins of ancient irrigation works; the development of this industry was temporarily checked when improved navigation and new modes of land locomotion permitted men to seek more genial climes; but now that the lands of the earth are filling up with enlightened men the irrigation industry has been renewed and is now being carried to higher perfection than ever before in the history of the earth; and although man has hardly learned to avoid or master floods, the running waters are already so far controlled that mills are driven, whole country-sides are irrigated, and waters are stored against the dry season in many lands, and the progress of intellectual development is thereby stimulated in a new way; and he is blind indeed who can not foresee that at no distant day the running waters of the earth will be wholly subjugated and sent hither and thither at man's behest.

Accordingly, through the development of navigation, the transformation of fisheries and the living things of the sea, and the control of streams and rivers, the waters of the earth are half subjugated; and the property conception has extended to the waters, and many rivers and lakes are parted among states and individuals as are the lands among countries and persons, and only the larger water bodies are common. Thus a large part of the waters of the earth have become subservient to man's needs; and the rivers, and to some extent the lakes and seas, are becoming creatures of human craft.

The evolution of Invention.—In the beginning, vitalized matter responded to various external forces and conditions, but the way from

simple responsivity to sustained inter-action or spontaneity was long; in the days of the lower organisms, when at first numbers, then individual might, and later bodily activity prevailed, the activities of the organisms were adjusted in harmony with an ever-widening range of external forces and conditions, and internal activity or spontaneity became characteristic; but the way from bodily spontaneity to the more perfect spontaneity of the highly organized brain, which, like the river, runs on and on and on throughout the life of the individual, was still longer; yet the whole course of development, first of living, then of moving, and finally of thinking beings, was one of increasing perfection of adjustment between the organism and its environment—the development of the most perfect congruity. Such was the beginning of knowledge—a series of inter-adjustments between the knowing organism and the great external. Now this stage in the development of knowledge coincided with the stage of discovery; men, like lower organisms, enjoyed and suffered contact with other living things, with matter in a variety of forms, with the forces of nature; and they selected and attuned themselves more perfectly unto the agreeable, and avoided the disagreeable; but the agreeable and useful came to them through the chance of endless cosmic activity, and were not selected or intelligently sought—and this was discovery.

As the number of inter-actions between brain substance and the outer world increased, spontaneity rose to a higher plane, and the mind gradually, by successive minute increments under the Law of Becoming, acquired the power of conscious prevision, of predicting future events from the course of events experienced in the past. Thus the spirit of prophecy was born, and the brain of the world expended a part of its force, first in the forecasting of the future, and then in devising means of avoiding the evil and securing the good, and this was the beginning of invention.

The transformation from discovery to invention was long and gradual; it began with the birth of cunning, long before the advent of man on the earth; and it has progressed cumulatively ever since, and is even now going on more rapidly than ever before. So this may justly be called the age of invention; for it is through this process that the ripest fruit of intellectual development has been gathered. It is largely through invention that the animals and plants of the earth have been subjugated and made subservient to human welfare; it is through invention that the conquest has been extended over the lands and waters of the earth that life may be made easier and safer, into the underworld that life may be made happier and more agreeable, into the microcosm that life may be lengthened, and into the macrocosm that the powers of the air may be enchained—it is through invention that the world has been transformed and the living things thereof made the creatures of intelligent man.

So it is in invention, child of the ages and sire of science, that the good and grand and glorious of the earth culminates; and it is invention that is ever transforming the earth, ever making for better things.

EPILOGUE.

The child of human parents is at first a helpless weakling, and must be fed, clothed, petted, nourished, and protected by those stronger than himself, and parents give freely of their life force that the child may be brought to maturity. When the human infant gains man's estate he repays with interest the debt unconsciously assumed in his infancy, supports his parents in their declining years, succors his fellow-men, and feeds, clothes, and protects the succeeding generation; and in this interchange of kindly acts lies the beauty and perfection of human life.

In like manner, mankind, offspring of mother earth, cradled and nursed through helpless infancy by things earthly, has been brought well toward maturity; and like the individual man he is repaying the debt unconsciously assumed at the birth of his kind by transforming the face of nature, by making all things better than they were before, by aiding the good and destroying the bad among animals and plants, and by protecting the aging earth from the ravages of time and failing strength, even as the child protects his fleshly mother. Such are the relations of earth and man.

